ACTUATOR SYSTEM FOR DISC DRIVE

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Related Application

This application claims priority of United States provisional application Serial Number 60/212,541 filed June 20, 2000 and United States provisional application Serial Number 60/212,216 filed June 16, 2000.

Field of the Invention

The present invention relates to an actuator assembly for a disc drive, and more specifically to disc drives utilizing alignment pins and alignment apertures in "top-down" assembly of actuator arm configurations.

Background of the Invention

Disc drives are data storage devices that store digital data in magnetic form on a storage medium on a rotating data disc. Modern disc drives comprise one or more rigid data discs that are coated with a magnetizable medium and mounted on the hub of a spindle motor for rotation at a constant high speed. An array of data transducers are mounted to an actuator arm and a servo system is used to move the actuator arm such that a particular transducer is positioned over a desired location for writing or reading information to and from the disc. During a write operation, the transducer writes data onto the disc and during a read operation the transducer senses the data previously written on the disc and transfers the information to an external environment.

There is a continuing push for disc drives with smaller physical dimensions. Smaller sized disc drives, however, are generally difficult to manufacture due to the complex assembly of conventional disc drives. Typical disc drives, for example, include a multiple arm housing that allows multiple head gimbal assemblies to be attached. A coil in a voice coil motor is generally attached to the housing by either adhesive bonding or overmolding. Moreover, a

bearing cartridge and side mounted pre-amplifier circuit is also typically attached to the housing. Such arrangements tend to increase the physical size of conventional disc drives to greater than desirable dimensions.

Summary

Embodiments of the present invention solve the above and other problems by mounting an arm circuit in a "top-down" configuration on the top or bottom surface of an actuator arm using alignment pins and alignment apertures. Thus, an embodiment generally involves an actuator assembly for reading and writing data from and to a data disc. The actuator assembly includes an actuator arm rotatably mounted adjacent the data disc. The actuator arm has a top surface and a bottom surface, and includes a head gimbal assembly support portion located at one end of the actuator arm. The actuator assembly includes an arm circuit fastened to the top surface of the actuator arm. The actuator assembly further includes an arm circuit alignment aperture on the arm circuit and an arm circuit alignment pin on the actuator arm. The arm circuit alignment aperture receives the arm circuit alignment pin for positioning of the arm circuit on the top surface of the actuator arm.

The actuator assembly includes a head gimbal assembly. The head gimbal assembly is fastened to the head gimbal assembly support portion of the actuator arm and contains a data transducer for writing and reading data to and from the data disc. Furthermore, the actuator assembly may include a gimbal circuit that electrically couples the data transducer and the arm circuit. The gimbal circuit is partially routed along the head gimbal assembly and over the top surface of the actuator arm. The actuator assembly in accordance with an embodiment also includes a gimbal circuit alignment aperture on the gimbal circuit and a gimbal circuit alignment pin on the actuator arm. The gimbal circuit alignment aperture receives the gimbal circuit alignment pin to position of the gimbal circuit accurately over and on the top surface of the actuator arm. The head gimbal assembly can then be swaged, laser-welded, or screw mounted to the actuator arm.

These and various other features as well as advantages, which characterize an embodiment of the present invention, will be apparent from a reading of the following detailed description and a review of the associated drawings.

Brief Description of the Drawings

Fig. 1 shows a disc drive constructed in accordance with one embodiment of the present invention.

Fig. 2 is a perspective view of the actuator assembly removed from the disc drive shown in **Fig. 1**.

Fig. 3 shows another embodiment of the present invention with an arm circuit mounted on a bottom surface of an actuator arm.

Fig. 4 shows a detailed view of the arm circuit and gimbal circuit of the actuator assemblies utilized in **Fig. 2** and **Fig. 3**.

Fig. 5 shows another embodiment of the present invention having connecting pads oriented along one side of the arm circuit.

Detailed Description

Embodiments of the invention are described in detail below with reference to the figures. When referring to the figures, like structures and elements shown throughout are indicated with like reference numerals.

A disc drive **102** constructed in accordance with an embodiment of the present invention is shown in **Fig. 1**. The disc drive **102** includes a base **104** to which various components of the disc drive are mounted. A top cover **106**, shown partially cut away, cooperates with the base **104** to form an internal field environment for the disc drive in a conventional manner. The components of the disc drive **102** include a spindle motor **108** which rotates one or more discs **110** at a constant high speed. Information is written to and read from tracks on the discs **110** through the use of an actuator assembly **112**, which rotates

during a seek operation about a bearing shaft assembly **114** positioned adjacent to the discs **110**. The actuator assembly **112** includes one or more actuator arms **116** which extend toward the discs **110**, with one or more head gimbal assemblies **118** extending from a proximate end of each of the actuator arms **116**. Mounted at one end of each of the head gimbal assemblies **118** is at least one data transducer **120** which includes an air-bearing slider enabling the transducer **120** to fly in close proximity above the corresponding surface of the associated disc **110**.

During a seek operation, the track position of the data transducers **120** is controlled through the use of a voice coil motor (VCM) **122**, which typically includes an actuator coil **124** attached to the actuator assembly **112**, as well as one or more permanent magnets **126** establishing a magnetic field in which the actuator coil **124** is immersed. Controlled application of current to the actuator coil **124** causes magnetic interaction between the permanent magnets **126** and the actuator coil **124** so that the actuator coil **124** moves in accordance with the well known Lorentz relationship. As the actuator coil **124** moves, the actuator assembly **112** pivots about the bearing shaft assembly **114**, and the data transducers **120** are caused to move across the surfaces of the discs **110**.

As discussed in greater detail below, a circuit assembly **128** provides the requisite electrical connection paths for the actuator assembly **112** while allowing pivotal movement of the actuator assembly **112** during operation. The circuit assembly **128** includes an L-shaped gimbal circuit **130** coupled with the data transducer **120** and partially routed along the head gimbal assembly **118**. An arm circuit **132**, coupled with the gimbal circuit **130**, is mounted on the actuator arm **116**. The arm circuit **132** typically includes circuitry for controlling write currents applied to the data transducer **120** during write operations and preamplifiers for amplifying read signals generated by the data transducer **120** during read operations. The arm circuit is comprised of a flexible ribbon lead portion **133** and a signal conditioning portion **132**. The flexible ribbon lead portion **133** of the arm circuit is connected to the signal conditioning portion **132** and a flex connector **134** to electrically couple the signal conditioning portion **132** to the flex connector **134**. The flex connector **134** electrically couples the arm circuit **132** to

the printed circuit board (not shown) and may be supported by a flex bracket **136** rigidly mounted on to the base **104**. The arm circuit **132** communicates signals through the flex connector **134** to the disc drive printed circuit board (not shown) mounted to the bottom side of the disc drive **102**.

In **Fig. 2**, one embodiment of the actuator assembly **112** in accordance with the present invention is shown. The actuator assembly **112** includes an elongated actuator arm **116** for moving the data transducer **120** across the data disc **110**. The actuator arm **116** is preferably constructed from a lightweight material to reduce inertial forces during arm movement. For example, the actuator arm **116** can be fabricated from aluminum or a hard plastic. In one embodiment of the present invention, the actuator arm **116** is formed by a sheet metal stamping technique which achieves lightweight, low inertia and low profile arm properties. Fabricating the actuator arm **116** to the desired shape and size by sheet metal stamping is generally less time-consuming and less expensive than conventional machining approaches to forming an actuator arm.

The actuator arm **116** includes a substantially V-shaped coil support portion **202** at its distal end **204**. The coil support portion **202** is configured to contain the actuator coil **124**, thereby creating a mechanism for movement of the actuator arm **116** across the data disc **110**. It is contemplated that the actuator coil **124** may be attached to the actuator arm **116** by adhesively bonding the actuator coil **124** to the actuator arm **116**, over-molding the actuator coil **124** to the actuator arm **116**, or by using other similar techniques.

The actuator arm **116** includes a head gimbal support portion **206** at its proximate end which receives the head gimbal assembly **118**. In accordance with one embodiment of the present invention, the head gimbal assembly **118** may be swaged to a bottom surface **216** of the actuator arm **116.** Alternatively, the head gimbal assembly **118** may be laser welded or screw mounted directly onto the actuator arm **116**. As described below, at least one data transducer **120** is mounted to the head gimbal assembly **118** for writing and reading data to and from the data disc **110**.

A pivot bearing support portion **210** is located between the proximate end **208** and the distal end **204** of the actuator arm **116**, and is designed to receive a pivot bearing **212** and a bearing shaft **214**. It is contemplated that the actuator arm **116** may serve as the bearing housing sleeve of the pivot bearing **212**, thus retaining the bearings and eliminating the use of a separate bearing housing sleeve. It is contemplated that the pivot bearing **212** may be attached to the actuator arm **116** by adhesively bonding the pivot bearing **212** to the actuator arm **116**, press-fitting the pivot bearing **212** to the actuator arm **116**. Similarly, the bearing shaft **214** can be attached to the pivot bearing **212** by adhesively bonding the bearing shaft **214** to the pivot bearing **212**, press-fitting the bearing shaft **214** to the pivot bearing **212**.

As mentioned earlier, the circuit assembly **128** provides an electrical path for data signals from the data transducer **120** to the flex connector **134**. The circuit assembly **128** includes the arm circuit **132** that amplifies signals which originate from the data transducer **120** and travel along the gimbal circuit **130**. In general, the voltage levels of data signals passing from the data transducer **120** to the arm circuit **132** are extremely small (in the order of micro-volts). Consequently, relatively small amounts of noise introduced to such data signals can have a profound effect on the signal-to-noise ratio of these signals and degrade disc drive performance. Generally speaking, the noise level of data signals from the data transducer **120** to the arm circuit **132** is proportional to the distance traveled by the data signals from the data transducer **120** to the arm circuit **132**. In other words, as the signal path from the data transducer **120** to the arm circuit **132** increases, the signal-to-noise ratio of the data signal decreases.

In accordance with one embodiment of the present invention, the arm circuit **132** is mounted on a top surface **218** of the actuator arm **116** along the circuit assembly **128**. This "top-down" configuration of the arm circuit **132** on the actuator arm **116** brings the arm circuit **132** beneficially closer to the data transducer **120**. By reducing the read/write signal transmission distance between the arm circuit **132** and the data transducer **120**, less noise is introduced to the read/write signal. Consequently, overall disc drive performance is enhanced when the present invention is utilized.

The present invention may be further configured such that the gimbal circuit **130** is partially routed along the head gimbal assembly **118** and over the top surface **218** of the actuator arm **116**. Coupling pads (not shown) on the gimbal circuit **130** and the arm circuit **132** may be used to electrically connect the data transducer **120** with the arm circuit **132**. In another embodiment of the present invention, protruding integrated arm circuit guides **230** on the actuator arm **116** are utilized to secure, bend, and route a flexible ribbon lead portion **133** of the arm circuit **132** within the disc drive **102**. The flexible ribbon lead portion **133** of the arm circuit electrically couples the signal conditioning portion **132** of the arm circuit to the flex connector **134** so that data signals can be communicated to and from the printed circuit board (not shown). The electrical circuit comprised of the gimbal circuit **130**, the signal conditioning portion **132**, the flexible ribbon lead portion **133**, and the flex connector **134**, electrically couples the data transducer **120** to the printed circuit board.

In **Fig. 3**, an embodiment of the present invention is shown with the arm circuit **132** mounted on the bottom surface **216** of the actuator arm **116**. In this embodiment, the advantageous placement of the arm circuit **132** proximate the data transducer **120**, as described above, is also achieved. It is contemplated that the arm circuit **132** is fastened to the actuator arm **116** using mounting techniques known to those skilled in the art, including adhesive bonding, soldering, crimping, and screw fastening techniques.

In **Fig. 4**, a detailed view of the arm circuit **132** and the gimbal circuit **130** is shown. A transducer portion **402** of the gimbal circuit **130** electrically couples the gimbal circuit **130** to the data transducer **120** and is disposed on a proximate end **404** of the head gimbal assembly **118**. It is contemplated that the transducer portion **402** of the gimbal circuit **130** is chemically bonded or soldered to the proximate end **404** of the head gimbal assembly **118**, however other fastening techniques known to those skilled in the art may be used. As shown, the transducer portion **402** of the gimbal circuit **130** may be forked about both sides of the data transducer **120**, thereby providing equal balance around the data transducer **120**.

From the proximate end **404** of the head gimbal assembly **118**, the gimbal circuit **130** continues up the head gimbal assembly **118** and is partially routed along one side of the head

gimbal assembly **118**. At the head gimbal support portion **206** of the actuator arm **116**, the gimbal circuit **130** is elevated and fastened over the actuator arm **116** and the arm circuit **132**. Connecting pads **406** on the gimbal circuit **130** and the arm circuit **132** electrically couple the gimbal circuit **130** to the arm circuit **132**. Unlike prior approaches, the arm circuit **132** is positioned at the proximate end **208** of the actuator arm **116**, which improves read/write signal quality over prior approaches wherein the preamplifier is significantly farther from the transducer. Also, positioning the connecting pads **406** on the top surface of the actuator arm **116** allows for top-down assembly and automation of inter-connects attachment. Positioning the connecting pads **406** on the top surface **218** of the actuator arm **116** substantially eliminates the need to bend the gimbal circuit **130** surrounding the connecting pads **406** region as in the side-mounting approaches. Further to this, arm grooving features along the arm edges used in prior approaches for capturing and guiding the gimbal circuit can be eliminated. Similar advantages are achieved by mounting the connecting pads **406** on the bottom surface (**216** of Fig. **3**) of the actuator arm **116**.

In another embodiment of the present invention, the actuator assembly **112** may include alignment pins **412** to help align the gimbal circuit **130** with the arm circuit **132**. For example, the gimbal circuit **130** may include one or more gimbal circuit alignment apertures **410** which receive a gimbal circuit alignment pin **412** and aligns the gimbal circuit **130** to a gimbal circuit mounted position **414** on the top surface **218** of the elongated actuator arm **116**. Likewise, the arm circuit **132** may include one or more arm circuit alignment apertures **416** which receive arm circuit alignment pins **418** to position and align the arm circuit **132** on the top surface **218** of the actuator arm **116** at an arm circuit mounted position **420**. Utilizing the alignment apertures **410** and **416** and the alignment pins **412** and **418** helps ensure proper electrical connections between the gimbal circuit **130** and the arm circuit **132** along the connecting pads **406** during manufacturing of the actuator assembly **112**.

In **Fig. 5**, another embodiment of the present invention is shown. In this embodiment, the connecting pads **406** are oriented along a side of the arm **132**. It is contemplated that the connecting pads **406** may be aligned along the left side **502**, the right side **503**, or a

combination thereof. As described above, alignment pins **412** and **418** may also be utilized to help ensure proper electrical connections between the gimbal circuit **130** and the arm circuit **132** along the connecting pads **406** during manufacturing of the actuator assembly **112**. As in the embodiment of Fig. **4**, the arm circuit **132** is positioned at the proximate end **208** of the actuator arm **116**, thereby improving the quality of read/write signals over prior approaches wherein the preamplifier is significantly farther from the transducer. Aligning the connecting pads **406** along the sides of the actuator arm **116**, and positioning the connecting pads **406** on the top surface **218** or the bottom surface **216** of the actuator arm **116**, allows for top-down assembly and automation of inter-connects attachment during the manufacturing process.

In summary, and in view of the foregoing discussion, it will be understood that one embodiment of the present invention provides an actuator assembly (such as **112**) for reading and writing data from and to a data disc (such as **110**). The actuator assembly (such as **112**) includes an actuator arm (such as **116**) rotatably mounted adjacent the data disc (such as **110**). The actuator arm (such as **116**) has a top surface (such as **218**) and a bottom surface (such as **216**), and includes a head gimbal assembly support portion (such as **206**) located at a proximate end (such as **208**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) includes an arm circuit (such as **132**) fastened to the top surface (such as **218**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) additionally includes an arm circuit alignment aperture (such as **416**) on the arm circuit (such as **132**) and an arm circuit alignment pin (such as **418**) on the actuator arm (such as **116**). The arm circuit alignment aperture (such as **416**) receives the arm circuit alignment pin (such as **418**) for positioning of the arm circuit (such as **132**) on the top surface (such as **218**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) also includes an integrated arm circuit guide (such as **230**) routing the arm circuit (such as **132**).

In another embodiment, the actuator assembly (such as **112**) includes a head gimbal assembly (such as **118**). The head gimbal assembly (such as **118**) is fastened to the head gimbal assembly support portion (such as **206**) of the actuator arm (such as **116**) and contains a data transducer (such as **120**) for writing and reading data to and from the data disc (such as

110). Furthermore, the actuator assembly (such as **112**) may include a gimbal circuit (such as **130**) that electrically couples the data transducer (such as **120**) and the arm circuit (such as **132**). The gimbal circuit (such as **130**) is partially routed along the head gimbal assembly (such as **118**) and over the top surface (such as **218**) of the actuator arm (such as **116**). An embodiment may also include a gimbal circuit alignment aperture (such as **410**) on the gimbal circuit (such as **130**) and a gimbal circuit alignment pin (such as **412**) on the actuator arm (such as **116**). The gimbal circuit alignment aperture (such as **410**) receives the gimbal circuit alignment pin (such as **412**) for positioning of the gimbal circuit (such as **130**) on the top surface (such as **218**) of the actuator arm (such as **116**). The head gimbal assembly (such as **118**) can be swaged, laser-welded, or screw mounted to the actuator arm.

In another embodiment, the actuator arm (such as **116**) includes a substantially V-shaped coil support portion (such as **204**) located at a distal end (such as **202**) of the actuator arm (such as **116**). Furthermore, the actuator assembly (such as **112**) includes an actuator coil (such as **124**) fastened to the V-shaped coil support portion (such as **204**) of the actuator arm (such as **116**). The actuator coil (such as **124**) may be adhesive-bonded or overmolded to the actuator arm (such as **116**).

In another embodiment, the actuator arm (such as **116**) includes a pivot bearing support portion (such as **210**) located between the proximate end (such as **208**) and the distal end (such as **202**) of the actuator arm (such as **116**). Additionally, the actuator assembly (such as **112**) includes a pivot bearing (such as **212**) coupled directly to the actuator arm (such as **116**) at the pivot bearing support portion (such as **210**).

In another embodiment, an actuator assembly (such as **112**) for reading and writing data from and to a data disc (such as **110**) is presented. The actuator assembly (such as **112**) includes an actuator arm (such as **116**) rotatably mounted adjacent the data disc (such as **110**). The actuator arm (such as **116**) has a top surface (such as **218**) and bottom surface (such as **216**), with an arm circuit (such as **132**) mounted to the top surface (such as **218**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) further includes a head gimbal assembly (such as **118**) operably connected to the actuator arm (such as **116**) at the bottom

surface (such as **216**). The head gimbal assembly (such as **118**) contains a data transducer (such as **120**) for writing and reading data to and from the data disc (such as **110**). In addition, a gimbal circuit (such as **130**) is electrically coupled with the data transducer (such as **120**) and the arm circuit (such as **132**), and is partially positioned along the head gimbal assembly (such as **118**) and partially positioned along the top surface (such as **218**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) includes one or more arm circuit alignment pins (such as **418**) on the top surface (such as **218**) of the actuator arm (such as **116**) which are configured to align the arm circuit (such as **132**) to an arm circuit mounted position (such as **420**) on the top surface (such as **218**) of the actuator arm (such as **116**).

Alternatively, in another embodiment, the top surface (such as **218**) of the actuator arm (such as **116**) includes one or more gimbal circuit alignment pins (such as **412**) configured to align the gimbal circuit (such as **130**) to a gimbal circuit mounted position (such as **414**) on the top surface (such as **218**) of the actuator arm (such as **116**).

Another embodiment includes an actuator assembly (such as **112**) for reading and writing data from and to a data disc (such as **110**) having an elongated actuator arm (such as **116**) rotatably mounted adjacent the data disc (such as **110**). The actuator arm (such as **116**) includes a substantially V-shaped coil support portion (such as **204**) located at a distal end (such as **202**) of the actuator arm (such as **116**), a head gimbal assembly support portion (such as **206**) located at a proximate end (such as **208**) of the actuator arm (such as **116**), and a pivot bearing support portion (such as **212**) located between the proximate end (such as **208**) and the distal end (such as **202**) of the actuator arm (such as **116**). The actuator arm (such as **116**) further includes a top surface (such as **218**) and bottom surface (such as **216**). The actuator assembly (such as **112**) also comprises an arm circuit (such as **132**) fastened to the top surface (such as **218**) of the actuator arm (such as **116**) between the pivot bearing support portion (such as **212**) and the head gimbal assembly support portion (such as **206**).

The actuator assembly (such as **112**) may additionally include an arm circuit alignment aperture (such as **416**) on the arm circuit (such as **132**) and an arm circuit alignment pin (such as **418**) on the actuator arm (such as **116**). The arm circuit alignment aperture (such as **416**)

receives the arm circuit alignment pin (such as **418**) for positioning of the arm circuit (such as **132**) on the top surface (such as **218**) of the actuator arm (such as **116**).

In another embodiment, the actuator assembly (such as **112**) includes a head gimbal assembly (such as **118**). The head gimbal assembly (such as **118**) contains a data transducer (such as **120**) for writing and reading data to and from the data disc (such as **110**), and is fastened to the head gimbal assembly support portion (such as **206**) of the actuator arm (such as **116**). Additionally, the actuator assembly (such as **112**) may include a gimbal circuit (such as **130**) that electrically couples the data transducer (such as **120**) with the arm circuit (such as **132**). The gimbal circuit (such as **130**) is partially routed along the head gimbal assembly (such as **118**) and over the top surface (such as **218**) of the actuator arm (such as **116**). An embodiment may also include a gimbal circuit alignment aperture (such as **410**) on the gimbal circuit (such as **130**) and a gimbal circuit alignment pin (such as **412**) on the actuator arm (such as **116**). The gimbal circuit alignment aperture (such as **410**) receives the gimbal circuit alignment pin (such as **412**) for positioning of the gimbal circuit (such as **130**) on the top surface (such as **218**) of the actuator arm (such as **116**).

In yet another embodiment, an actuator assembly (such as **112**) is configured for reading and writing data from and to a data disc (such as **110**). The actuator assembly (such as **112**) includes an elongated actuator arm (such as **116**) rotatably mounted adjacent the data disc (such as **110**). The actuator arm (such as **116**) includes a substantially V-shaped coil support portion (such as **204**) located at a distal end (such as **202**) of the actuator arm (such as **116**), a head gimbal assembly support portion (such as **206**) located at a proximate end (such as **208**) of the actuator arm (such as **116**), and a pivot bearing support portion (such as **210**) located between the proximate end (such as **208**) and the distal end (such as **202**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) further includes an arm circuit (such as **132**) fastened to the bottom surface (such as **216**) of the actuator arm (such as **116**). The actuator assembly (such as **112**) also includes an arm circuit alignment aperture (such as **416**) on the arm circuit (such as **132**) and an arm circuit alignment pin (such as **418**) on the actuator arm (such as **116**). The arm circuit alignment aperture (such as **416**) receives the arm circuit

alignment pin (such as **418**) for positioning of the arm circuit (such as **132**) on the bottom surface (such as **216**) of the actuator arm (such as **116**).

In addition, the actuator assembly (such as **112**) may include a head gimbal assembly (such as **118**) with a data transducer (such as **120**) for writing and reading data to and from the data disc (such as **110**). The head gimbal assembly (such as **120**) is fastened to the head gimbal assembly support portion (such as **206**) of the actuator arm (such as **116**). A gimbal circuit (such as **130**) can be used to electrically couple the data transducer (such as **120**) and the arm circuit (such as **132**), and is partially routed along the head gimbal assembly (such as **118**) and under the bottom surface (such as **216**) of the actuator arm (such as **116**). Moreover, an embodiment may include a gimbal circuit alignment aperture (such as **410**) on the gimbal circuit (such as **130**) and a gimbal circuit alignment pin (such as **412**) on the actuator arm (such as **116**). The gimbal circuit alignment aperture (such as **410**) receives the gimbal circuit alignment pin (such as **412**) for positioning of the gimbal circuit (such as **130**) along the bottom surface (such as **216**) of the actuator arm (such as **116**).

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While the presently preferred embodiments have been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. For example, the present invention may be adapted for use in an optical disc drive configuration, such as a Compact Disk (CD) or Digital Versatile Disk (DVD). Thus, numerous other changes, combinations, and arrangements of techniques may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.